Since the materials laboratory became operational in June 1987, it has generated considerable interest within industry. The amount of user research carried out in the four User Centers has steadily increased since the first user agreement was signed in July 1987. By September 30, 1989, 27 universities, 24 industrial companies, and 3 government facilities had signed agreements to use the facility.

In August 1989, Coors Ceramics Co., the nation's largest producer of precision technical ceramics, announced its decision to build a ceramics production plant in Oak Ridge, Tennessee. Proximity to the High-Temperature Materials Laboratory and to the technology transfer opportunities from DOE's ceramic technology programs at the Oak Ridge National Laboratory were cited as major factors in Coors' decision to locate in the area.

Gel Casting

A method was needed to form ceramic materials into complex shapes at a high rate of production but at a relatively low cost. DOE research carried out under the Advanced Materials Development Program led to the novel method of gel-casting ceramic powders. This method overcomes the shortcomings of injection molding by separating the mold-filling operation from the setting operation. A water-based vehicle is used instead of a 100% wax- or polymer-based vehicle. The method also uses a new setting mechanism that is different from current practice. The outcome of this fast and economical technique is predictable, allowing product dimensions to be closely controlled.

The successful production of tensile and other alumina oxide ceramic specimens demonstrated the potential for gel-casting technology. Collaborative research agreements are being initiated to develop this technique for processing high-performance silicon nitride. The gel-casting process for other ceramics has already been licensed to a major U.S. ceramics manufacturer.

Silicon Nitride Powder

New engine technologies will rely upon ceramic engine parts that are lightweight, extend the life of engines (particularly car engines), and promote energy efficiency. Reliable and cost-effective ceramic components for these advanced engines are a major focus of DOE's Advanced Materials Development Program research. To date, their application has been limited by the inability to produce large volumes of quality material. Efforts within the program have focused on improving ceramics processing techniques. Recently, DOE-supported research has led to the development of a patented technique for producing high-quality silicon nitride powder for ceramic components. The process is based on the low-temperature reduction of silicon chloride with ammonia.

A pilot plant has been designed for this process and discussions held with several chemical companies regarding potential technology licensing for domestic production.

Microwave Processing of Ceramic Materials

DOE has funded research to demonstrate the benefits of microwave processing of ceramic materials such as alumina. This technique has potential to facilitate fabrication of near–net-shaped components with the same properties as those produced using the conventional hot-pressed method. Microwave processing, by using pressureless sintering at lower temperatures, has the potential to save energy and reduce process cycle time through uniform, rapid heating of large shapes. The cost-reducing advantages of the increased throughput made possible by microwave processing include decreased operating inventories and increased manufacturing capacity. By lowering sintering temperatures and using selective coupling techniques, a whole new range of microstructures could potentially be created.

Sintering and microstructural studies on alumina showed that at 28 gigahertz, well beyond the normal commercially used frequency, large pieces of high-purity alumina can be uniformly heated and sintered. Densification of the material heated in the microwave field was significantly more rapid than that exhibited during conventional infrared processes. The apparent activation energy required for the microwave sintering process was also shown to be much lower than that required in current processing techniques. Together, these two factors indicate the enormous industrial potential of microwave sintering in terms of greater throughput with less energy required.

There are numerous applications for microwave sintering and heat treating, including electrical ceramics (varistors, capacitors, integrated-circuit substrates), parts subject to friction and wear, catalyst